

PART IV: Cinematography & Mathematics

AGE RANGE: 13-15

TOOL 44: PRIME NUMBERS - THE MAN WHO KNEW INFINITY

Sandgårdskolan

Educator's Guide

Title: The man who knew infinity – prime numbers

Age Range: 13-15 years old

Duration: 2 hours

Mathematical Concepts: Prime numbers, Infinity

Artistic Concepts: Movie genres, Marvel heroes, vanishing point

General Objectives: This task will make you learn more about infinity. It wants you to think for yourself about the word infinity. What does it say to you? It will also show you the connection between infinity and prime numbers.

Resources: This tool provides pictures and videos for you to use in your classroom. The topics addressed in these resources will also be an inspiration for you to find other materials that you might find relevant in order to personalize and give nuance to your lesson.

Tips for the educator: Learning by doing has proven to be very efficient, especially with young learners with lower attention span and learning difficulties. Don't forget to always explain what each math concept is useful for, practically.

Desirable Outcomes and Competences: At the end of this tool, the student will be able to: Understand prime numbers and infinity in an improved way.

Explore super hero movies.

Debriefing and Evaluation:

Write 3 aspects that you liked about this activity:	1. 2. 3.
Write 2 aspects that you have learned:	1. 2.
Write 1 aspect for improvement:	1.

Introduction

Infinity is about things which never end ; an abstract concept describing something without any limit and refers to a collection of notions of boundlessness in mathematics, philosophy, and theology.

Infinity means many different things, depending on when it is used. The word is from a Latin word, which means "without end", Ad Infinitum/to infinity. Infinity goes on forever, so sometimes space, numbers, and other things are said to be 'infinite', because they never come to a stop.

Infinity is not really an ordinary number, but it is sometimes used as one. Infinity often says how many there is of something, instead of how big something is. For example, there are infinitely many whole numbers (called integers), but there is no integer which is infinitely big. But different kinds of math have different kinds of infinity. So its meaning often changes.



Picture 1 Infinity symbol [Wikimedia Commons](#)

The man who knew infinity

The movie *The Man Who Knew Infinity* is about Srinivasa Ramanujan, who is generally viewed by mathematicians as one of the two most romantic figures in the discipline of mathematics.



Picture 2: Srinivasa Ramanujan. [Wikimedia Commons](#)

Ramanujan (1887–1920) was born in southern India and died at the same part, aged just 32, . But in one of the most extraordinary events in mathematical history, he spent the period of World War I in Trinity College Cambridge at the invitation of the leading British mathematician Godfrey Harold (G. H.) Hardy (1877–1947) and his great collaborator John E. Littlewood.

As a boy he refused to learn anything but mathematics, he was almost entirely self-taught and his pre-Cambridge work is contained in a series of notebooks.

The work he did after returning to India in 1919 is contained in the misleadingly named *Lost Notebook*. It was found later in the library of Wren college for mathematics. While in England Ramanujan became the first Indian Fellow in both Trinity and the Royal Society.

A man of numbers

Ramanujan had an extraordinary ability to see patterns. While he rarely proved his results he left a host of evaluations of sums and integrals. He was especially expert in a

part of number theory called modular forms which is of even more interest today than when he died.

The Lost Notebook initiated the study of mock theta functions which are only now being fully understood. Fleshing out his Notebooks has only recently been completed principally by American mathematicians Prof Bruce Berndt and Prof George Andrews. It comprises thousands of printed pages.

The Nobel prize winning astronomer Subrahmanyan Chandrasekhar, described how important Ramanujan's success in England had been to the self-confidence of himself and the founders of modern India including Jawaharlal Nehru, who became the first prime minister of independent India in 1947.

In 2008 David Leavitt published a novelised version of Ramanujan's life entitled the Indian Clerk. While Leavitt captures much beautifully, as a novelist, he takes some sizeable liberties and includes details about Ramanujan's private life (as opposed to his professional one as a mathematician)

In 2012 on the 125th anniversary of Ramanujan's birth the Notices of the American Mathematical Society published eight articles on his work. This suite forcibly showed how Ramanujan's reputation and impact continue to grow.

A final anecdote describes Ramanujan and his fascination with mathematics nicely. In 1917 Ramanujan was hospitalised in London and visited by his colleague Hardy. Not being good at small talk all Hardy could think of saying was that the number of his cab, 1,729, was uninteresting. Ramanujan replied that quite to the contrary it was the smallest number expressible as a sum of two cubes in two distinct ways:

1,729 is the smallest number which can be represented in two different ways as the sum of two cubes:

$$\begin{aligned}1729 &= 1^3 + 12^3 \\ &= 9^3 + 10^3\end{aligned}$$

It is also incidentally the product of 3 prime numbers:

$$1729 = 7 \times 13 \times 19$$

The largest known similar number is:

$$\begin{aligned}885623890831 &= 7511^3 + 7730^3 \\ &= 8759^3 + 5978^3 \\ &= 3943 \times 14737 \times 15241\end{aligned}$$

Picture 2Hardy-Ramanujan "taxicab Numbers" [Wikimedia Commons](#)

More movies about mathematicians

There have been a lot of books, plays and movies, and TV series such as "The Big Bang Theory" about mathematicians and theoretical physicists. Especially the series "The Big Bang Theory" has set mathematics, physics and philosophy on the map and the interest for studying these subjects has increased a lot.

Other interesting movies are A Beautiful Mind (2001), Copenhagen (2002), Proof (2005), The Imitation Game about Alan Turing and The Theory of Everything on Stephen Hawking.

Glossary

Subrahmanyan Chandrasekhar He was an American astro physicist of Tamil origin who was awarded the Nobel prize for Physics in 1983

David Leavitt He is an American writer who has written both fiction and non-fiction about famous mathematicians. His book *The Indian Clerk* is about Ramanujan and the book *The Man Who Knew Too Much* is about Alan Turing.

Jawaharlal Nehru He was a civil rights leader in India during the struggle for independence from Britain. He would become the first prime minister in India 1947. Both his daughter Indira Gandhi and grandson Rajiv Gandhi followed in his footsteps and later became prime ministers.

Theta functions These are special functions with many complex variables such as elliptic functions.

The Math behind The man who knew infinity

There are two kinds of infinity: potential infinity and actual infinity.

* **Potential infinity** is a process that never stops. For example, adding 10 to a number.

No matter how many times 10 is added, 10 more can still be added.

* **Actual infinity** is a more abstract idea. For example, there are infinitely many numbers as it is impossible to write them all down.

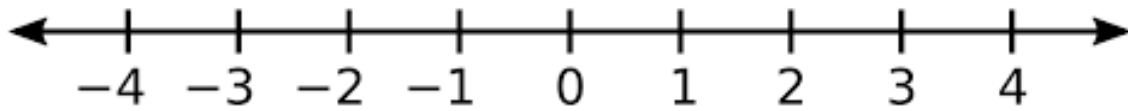
An early engagement with the idea of infinity was made by the Greek philosopher Anaximander who considered infinity to be a foundational and primitive basis of reality. Anaximander was the first in the Greek philosophical tradition to propose that the universe was infinite.

The Indian Jains (a religion practiced throughout India, according to Wikipedia the sixth biggest religion in the country) were the first to discard the idea that all infinities were the same or equal. They recognized different types of infinities:

- * infinite in length (one dimension),
- * infinite in area (two dimensions),
- * infinite in volume (three dimensions), and
- * infinite perpetually (infinite number of dimensions).

At the end of the 19th century, Georg Cantor introduced and studied infinite sets and infinite numbers, which are now an essential part of the foundation of mathematics.

For example, in modern mathematics, a line is viewed as the set of all its points, and their infinite number (the cardinality of the line) is larger than the number of integers.



Picture 3: Number line [Wikimedia Commons](#)

Thus the mathematical concept of infinity refines and extends the old philosophical concept. It is used everywhere in mathematics, even in areas, such as combinatorics and number theory that may seem to have nothing to do with it. For example, Wiles's proof of Fermat's Last Theorem uses the existence of very large infinite sets.

TASK

Hilbert's hotel

The Hilbert is the largest hotel in the world: it has infinitely many rooms. We could imagine that it consists of just a single, never-ending corridor, with the rooms numbered 1, 2, 3, 4 and so on. On the day we arrive at the Hilbert, every single room in the Hotel is full. (Business is going very well indeed...)

In any other hotel, the reception would have to turn us away: if all the rooms are full there simply isn't space for us. Very surprisingly, this is not the case at the Hilbert.

Once we arrive and ask for a room, the hotel makes a loudspeaker announcement that can be heard everywhere in the hotel: they ask all their guests to move up into the next room. Now the guest in room 1 moves into room 2, the guest in room 2 moves into room 3, and the guest in any room n moves into room $n+1$. Since there is no last room in the hotel, every guest will get a new room.

Now the first room is empty, and we can move in. Of course this wouldn't have worked in any finite hotel. We could still ask all guests to move up into the next room, but the person in the last room would be left without a room. The Hilbert doesn't have a last room, and infinity plus one is still infinity.

This idea can be extended: If 10 new guests arrive, the reception just asks all guests to move up 10 rooms. If 100 new guests arrive, all current guests have to move up 100 rooms – and similarly for any other number. Thus even if the hotel is full it can still offer rooms to any number of new guests!



Take an A3 sized white paper. Use a ruler and draw a picture of the hotel with only the walls and the roof. Start from the lower right corner of the building and draw 10 windows to indicate rooms. Now the next guest comes and you need one more room, since there is an infinite amount of rooms at the Hilbert's. How many rooms can you fit on one floor? What is it that will make your hotel have a finite amount of rooms?

LEARN MORE...

A Crash Course in the Mathematics Of Infinite Sets:

<http://legacy.earlham.edu/~peters/writing/infapp.htm>



A film about The man who knew infinity

<https://www.youtube.com/watch?v=P0idBBhGNgU>

About the series The Big Bang Theory

<https://the-big-bang-theory.com/>

Lesson on the geometry of Islamic design:

<https://www.youtube.com/watch?v=pg1NpMmPv48>

About Srinivasa Ramanujan

https://en.wikipedia.org/wiki/Srinivasa_Ramanujan

<http://www-history.mcs.st-and.ac.uk/Biographies/Ramanujan.html>



<https://www.youtube.com/watch?v=uGoUef1C3K0>

About infinity:

<https://en.wikipedia.org/wiki/Infinity>

<https://www.mathsisfun.com/numbers/infinity.html>

Why is the number 1729 known as the Ramanujan number?:

<https://www.quora.com/Why-is-the-number-1729-known-as-the-Ramanujan-number>

A really challenging equation posed by Ramanujan



<https://www.youtube.com/watch?v=r5BGli84arY>